Towards urban resilience through sustainable drainage systems: a multi-objective optimisation problem

Supplementary materials[1]

This section provides a summary of the key hydrological and hydraulics information used to build the analytical model in this study.

Table 3 – General information

Method	Horton
Build-up, Wash-off methods	Exponential
Min infiltration rate (mm/hr)	5
Max infiltration rate (mm/hr)	115
Decay (1/hr)	6
Evaporation: a time series (mm/day)	53.41

Table 4 – Build-up and wash-off parameters in the Mineirinho catchment

	Build-up									Wash-off								
	Max. buildup (kg/ha)			Rate constant			Coefficient			Exponent			Cleaning efficiency %			BMP efficiency %		
Land-use	TSS	TP	TN	TSS	P	TN	TSS	P	TN	TSS	P	TN	TSS	P	TN	TSS	P	TN
AGR*	337.96	0.00230	0.30	0.30	0.011	0.12	12.58	3.16	26.880	2.98	0.80	3.78	50	50	50	20	20	20
CGA*	37.54	0.00013	0.30	2.09	0.036	0.47	7.68	4.78	7.940	7.78	4.77	7.18	50	50	50	20	20	20
COM*	380.72	0.04900	0.26	0.32	0.011	0.23	11.24	0.77	25.690	4.54	0.51	5.32	50	50	50	20	20	20
FRS*	14.39	0.00011	0.22	0.58	0.018	0.19	3.54	2.37	4.250	5.37	1.38	5.40	50	50	50	20	20	20
IND*	448.91	0.05800	0.36	0.59	0.019	0.56	15.18	1.01	54.210	6.28	0.67	8.89	50	50	50	20	20	20
OPS*	214.87	0.00650	0.19	0.35	0.031	0.18	7.92	2.98	28.295	1.73	1.00	2.70	50	50	50	20	20	20
PNS*	18.77	0.00007	0.15	1.05	0.018	0.24	3.84	2.39	3.970	3.89	2.39	3.59	50	50	50	20	20	20
RDS*	117.29	0.00300	0.03	1.55	0.120	0.51	5.46	4.73	37.010	5.52	2.92	5.51	50	50	50	20	20	20
RGA*	37.54	0.00013	0.30	2.09	0.036	0.47	7.68	4.78	7.940	7.78	4.77	7.18	50	50	50	20	20	20
RSD*	18.00	0.03100	0.36	0.30	0.200	0.60	9.59	2.00	13.240	5.49	4.16	3.59	50	50	50	20	20	20

*AGR: Agriculture; CGA: Commercial Grass area; COM: Commercial; FRS: Forest; IND: Industrial; OPS: Open Space; PNS: Pines; RDS: Roads; RGA: Residential Grass area; RSD: Residential

Table 5 – GNR design parameters

Surface		Soil		Drainage mat/layer	
Berm height (mm)	30	Thickness (mm)	50	Thickness (mm)	3
Vegetation volume fraction	0.1	Porosity (volume fraction)	0.5	Void fraction	0.5
Surface roughness (Manning's n)	0.1	Field Capacity (volume fraction)	0.2	Roughness (Manning's n)	0.1
Surface slope (%)	1	Wilting point (volume fraction)	0.1		
		Seepage rate (mm/hr)	0.5		
		Conductivity slope	10		
		Suction head (mm)	3.5		

[1] Journal of Environmental Management, Vol 275, 1 December 2020, 111173 - https://doi.org/10.1016/j.jenvman.2020.111173

Table 6 – RNB design parameters

Storage depth (mm)	1000
Flow efficiency (mm/hr)	1
Flow exponent	0.5
Offset height (mm)	6
Drain delay (hr)	6

Table 7 – GSW design parameters

Berm height (mm)	600
Width (top, bottom) (m)	(3.0,1.0)
Vegetation volume fraction	0.3
Surface roughness (Manning's n)	0.368
Channel slope* (%)	7
Swale side slope (run/rise)	1:1

* the average slope of sub-catchments within the Mineirinho Catchment

Table 8 – PVP design parameters

Surface		**Soil**		**Pavement**		**Storage**		**Drain**	
Berm height (mm)	200	Thickness (mm)	500	Thickness (mm)	150	Thickness (mm)	600	Flow efficiency (mm/hr)	0
Vegetation volume fraction	0.1	Porosity (volume fraction)	0.5	Void ratio (voids/solids)	0.15	Void ratio (voids/solids)	0.74	Flow exponent	0.5
Surface roughness (Manning's n)	0.1	Field capacity (volume fraction)	0.2	Impervious surface fraction	0	Seepage rate (mm/hr)	0.5	Offset height (mm)	6
Surface slope (%)	7	Wilting point (volume fraction)	0.1	Permeability (mm/hr)	100	Clogging factor	0		
		Seepage rate (mm/hr)	0.5	Clogging factor	0				
		Conductivity slope	10						
		Suction head (mm)	3.5						

Table 9 – BIR design parameters in the Mineirinho catchment

Surface		**Soil**		**Storage**		**Drain**	
Berm height (mm)	300	Thickness (mm)	500	Thickness (mm)	2700	Flow efficiency (mm/hr)	0
Vegetation volume fraction	0.1	Porosity (volume fraction)	0.5	Void ratio (voids/solids)	0.75	Flow exponent	0.5
Surface roughness (Manning's n)	0.1	Field capacity (volume fraction)	0.2	Seepage rate (mm/hr)	0.5	Offset height (mm)	6
Surface slope (%)	5	Wilting point (volume fraction)	0.1	Clogging factor	0		
		Seepage rate (mm/hr)	0.5				

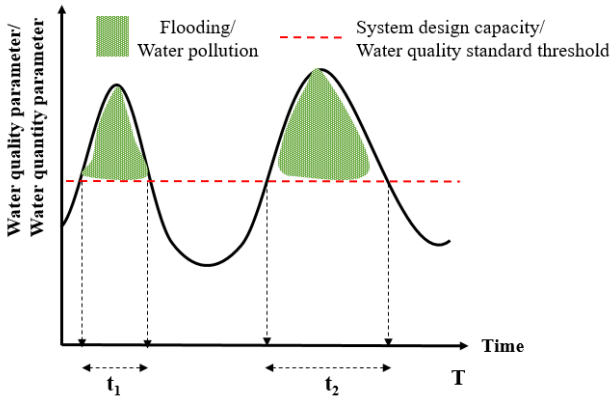

Fig. 1. Hypothetical flood resilience curve represents the excessive water beyond the design capacity of the drainage network over time; hypothetical water quality resilience curve demonstrates the violation of water quality from the defined water quality standards over time

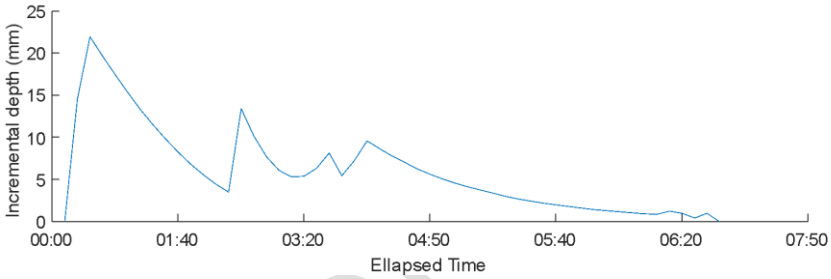

Fig. 2. The two-stage design storm rainfall pattern using Huff Heavy Storm equations